SLIDING COMPOSITION AND SLIDING MEMBER

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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority based on Japanese Patent Application No. 2002-277290, filed September 24, 2002, the entirety of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a sliding composition and a sliding member which do not contain lead for the purpose of reducing influences on the environment.

[0003] Polytetrafluoroethylenes (hereinafter referred to as PTFEs) excellent in self-lubricating properties have been used in sliding members for dry bearing and have been tried to be improved in wear resistance by addition of lead or the like (see, for example, JP-B-39-16950 (pp. 1 - 2)). When PTFE containing lead added thereto is used in a sliding member, it is transferred to a shaft supported by the sliding member because lead is effective in forming a film by the transfer. Thus, the PTFE forms the film on the shaft. Therefore, the sliding of the sliding member and the shaft on each other becomes the sliding of their PTFE films on each other, resulting in the following effect: the sliding member is excellent in frictional properties particularly when the sliding is conducted without lubrication. However, since lead has serious influences on the environment, bismuth (see, for example, JP-A-2001-221231 (p. 1)), barium sulfate (see, for example, JP-A-2002-20568 (pp. 1 - 2) or the like has been added as a substitute for lead.

[0004] However, although a sliding member obtained by adding bismuth (JP-A-2001-221231) or barium sulfate (JP-A-2002-20568) to PTFE used as a base resin possesses improved coefficient of friction and wear resistance, a further improved wear resistance at a high PV value has been desirable.

BRIEF SUMMARY OF THE INVENTION

[0005] The present invention was made in view of the above situation, and an object thereof is to further improve the wear resistance and frictional properties at a high PV value of a sliding composition and a sliding member.

[0006] For the achievement of the above object, the present invention provides a sliding composition comprising 50 to 80 vol% of a thermosetting resin, 10 to 40 vol% of a polytetrafluoroethylene having a molecular weight of 3,000,000 or more and 1 to 20 vol% of bismuth and/or a bismuth alloy; and a sliding member obtained by the use of said composition.

[0007] When the sliding composition has this make-up, the heat resistance, wear resistance and mechanical strength of the sliding member can be improved by the use of a thermosetting resin with a high mechanical strength as the base resin of the sliding composition. When the proportion of the thermosetting resin is less than 50 vol%, no sufficient mechanical strength can be attained, so that no sufficient wear resistance can be expected. When the proportion is more than 80 vol%, the effect of the addition of bismuth, an alkaline earth metal salt, PTFE and the like described hereinafter is lessened, so that no desirable frictional properties can be attained. The thermosetting resin includes phenolic resins, epoxy resins, polyimide resins, polyamide-imide resins, etc.

[0008] The adjustment of the molecular weight of the PTFE to 3,000,000 or more improves the wear resistance of the sliding composition and permits formation of a firm film by the transfer of the composition on a shaft supported by the sliding member. When the proportion of the PTFE ranges 10 to 40 vol% based on the total volume of the sliding composition, the formation of a firm film on the shaft by the transfer of the composition becomes possible, resulting in improved frictional properties. When the proportion is less then 10 vol%, no satisfactory frictional properties can be expected. When the proportion is more than 40 vol%, no desirable wear resistance can be attained.

[0009] Bismuth and the bismuth alloy have the effect of forming a film by the transfer of the composition on the shaft supported by the sliding member, so that they contribute to the improvement of the wear resistance when incorporated in a dispersed state into the resins in the sliding composition. The bismuth alloy is, for example, that obtained by incorporating silver, tin, zinc or indium into bismuth. A sliding composition containing

the bismuth alloy as an additive is harder than a sliding composition containing pure bismuth as an additive, and hence has a further improved wear resistance. The content of such a metal added to bismuth is preferably 0.5 to 30 mass%, more preferably 5 to 15 mass%, based on the total mass of bismuth. When the proportion of bismuth and/or the bismuth alloy is less than 1 vol% based on the total volume of the sliding composition, no satisfactory frictional wear properties can be expected. When the proportion is more than 20 vol%, the wear resistance is gradually deteriorated.

[0010] The present invention also provides a sliding composition comprising 50 to 80 vol% of a thermosetting resin, 10 to 40 vol% of a polytetrafluoroethylene having a molecular weight of 3,000,000 or more and 1 to 20 vol% of alkaline earth metal salt; and a sliding member obtained by the use of said composition.

[0011] When the sliding composition has this make-up, the same effects as those described above can be obtained because the alkaline earth metal salt has the effect of forming a film by the transfer of the composition on a shaft supported by the sliding member. When the proportion of the alkaline earth metal salt is less than 1 vol% based on the total volume of the sliding composition, no satisfactory frictional wear properties can be expected. When the proportion is more than 20 vol%, the wear resistance is gradually deteriorated. The alkaline earth metal salt includes, for example, phosphates, carbonates, silicates and sulfates, such as calcium phosphate, calcium carbonate, magnesium silicate, barium sulfate, etc. The alkaline earth metal salt in the present specification refers to Be, Mg, Ca, Sr, Ba or Ra.

[0012] Furthermore, the present invention provides a sliding composition comprising 50 to 80 vol% of a thermosetting resin, 10 to 40 vol% of a polytetra-fluoroethylene having a molecular weight of 3,000,000 or more and 1 to 20 vol% in total of bismuth or a bismuth alloy, or both and an alkaline earth metal salt; and a sliding member obtained by the use of said composition.

[0013] When the sliding composition has this make-up, the same effects as above can be obtained, namely, the sliding member is excellent in the heat resistance, wear resistance, chemical resistance, frictional properties and strength. Moreover, the sliding member possesses improved frictional wear properties not only when used without lubrication but also when used with lubrication. Therefore, excellent sliding becomes

possible owing to both these effects and the above-mentioned effects. The total adding amount of bismuth or the bismuth alloy, or both and the alkaline earth metal salt is preferably 1 to 20 vol% based on the total volume of the sliding composition.

[0014] In the present invention, each of the sliding compositions described above may further comprise 1 to 30 vol% of a solid lubricant.

[0015] When this making-up is employed, the resulting sliding composition can have more excellent frictional properties and wear resistance in either its use without lubrication or its use with lubrication. The proportion of the solid lubricant is preferably 1 to 30 vol% based on the total volume of the sliding composition. The solid lubricant includes graphite, molybdenum disulfide, tungsten disulfide, boron nitride, etc.

[0016] Each of the sliding compositions described above can be used for producing a sliding member by coating a substrate with the sliding composition. More preferably, a sliding member is produced by forming a porous layer on a substrate and coating the porous layer with said sliding composition by impregnation. When the sliding member is thus produced, the adhesion between the sliding composition and the substrate is firm, so that the sliding member has a high strength.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

[0018] **Fig. 1** is a cross-sectional view of a sliding member which shows one embodiment of the present invention.

[0019] In Fig. 1, numeral 1 denotes a sliding member, numeral 2 a plated copper film, numeral 3 a backing metal layer, numeral 4 a porous sintered metal layer, and numeral 5 a sliding composition.

DETAILED DESCRIPTION OF THE INVENTION

[0020] One embodiment of the present invention is explained below with reference to Fig. 1.

[0021] A section of a sliding member 1 is shown in Fig. 1. As shown in Fig. 1, the sliding member 1 is composed of a substrate, i.e., a backing metal layer 3 composed of a steel (low-carbon steel for common structure) plate and having a plated copper film 2 formed on the surface, and a sliding composition 5 coating the substrate through a porous sintered metal layer 4 of powder of a copper-based alloy by impregnation of this layer with the composition. The porous sintered metal layer 4 is joined in a powder state to the plated copper film and hence has numerous voids in its inside and surface portion.

[0022] Next, a process for producing the sliding member 1 shown in Fig. 1 is explained below.

[0023] First, powder of a copper-based alloy is spread on a backing metal layer 3 composed of a steel (low-carbon steel for common structure) plate of 1.2 mm thick and having a plated copper film formed on the surface, to a thickness of 0.3 mm. The backing layer 3 thus treated is heated at a temperature of 750 to 900°C in a reducing atmosphere to sinter the copper-based alloy powder, whereby a porous sintered metal layer 4 is obtained on the backing metal layer 3.

[0024] On the other hand, a sliding composition 5 is obtained in the form of a varnish by mixing the components shown in Table 1 in the proportions shown in Table 1. The porous sintered metal layer 4 on the aforesaid backing metal layer 3 is coated with the varnish-form sliding composition 5 by impregnation, after which the varnish-form sliding composition 5 is cured at a temperature of 150 to 250°C.

[0025] In order to verify the effect of the present invention, tests were carried out by the use of a thrust tester. In the tests for verification, the coefficient of friction and depth of wear of inventive sliding members and comparative sliding members were measured. Table 1 shows the results of the tests carried out.

[0026] Table 2 shows the test conditions. As to a criterion for judging the occurrence of seizure in the tests, it was judged by either a torque of more than 5 Kgf•m (49N•m)or a depth of wear of more than 50 μm.

Table 1

	Sample No.	Composition (vol%)	Conditions 1		Conditions 2	
			Coefficient of friction	depth of wear	Coefficient of friction	depth of wear
Comparative sliding member	(1)	PF resin	Seizure (torque over)		Seizure (torque over)	
	(2)	PF resin + 20 PTFE (1)	0.21	9 μm	Seizure (torque over)	
	(3)	PF resin + 20 PTFE (2)	0.23	14 μm	Seizure (torque over)	
	(4)	PF resin + 20 barium sulfate	0.23	13 μm	Seizure (torque over)	
	(5)	PF resin + 40 graphite	0.22	15 μm	Seizure (torque over)	
	(6)	PTFE + 20 lead	0.13	21 μm	Seizure (torque over) + marked wear	
	(7)	PTFE + 20 bismuth	0.12	25 μm	Seizure (torque over) + marked wear	
	(8)	PTFE + 20 barium sulfate	0.18	30 μm	Seizure (torque over) + marked wear	
	(9)	PTFE + 10 barium sulfate + 5 graphite + 5 molybdenum disulfide	0.15	23 μm	Seizure (torque over) + marked wear	

Cont'd ...

Table 1 (Cont'd ...)

Inventive sliding member	(1)	PF resin + 20 PTFE (1) + 10 bismuth	0.14	11 μm	0.10	23 μm
	(2)	PF resin + 20 PTFE (1) + 10 barium sulfate	0.16	15 μm	0.11	30 μm
	(3)	PF resin + 20 PTFE (1) + 5 bismuth + 5 calcium carbonate	0.15	14 μm	0.11	28 μm
	(4)	PF resin + 20 PTFE (1) + 10 barium sulfate + 5 graphite + 5 molybdenum disulfide	0.12	15 μm	0.10	29 μm
	(5)	PF resin + 20 PTFE (1) + 5 bismuth + 5 barium sulfate + 5 graphite + 5 molybdenum disulfide	0.11	15 μm	0.10	27 μm

Table 2

	Conditions 1
Speed	6 m/min
Load	5 MPa
Lubrication	No lubrication
Test time	4 hrs
Material for a shaft supported by a sliding member	S55C
Roughness	Ry 2 - 3 μm
Hardness	HV 200 - 300

	Conditions 2
Speed	12 m/min
Load	10 MPa
Lubrication	No lubrication
Test time	4 hrs
Material for a shaft supported by a sliding member	S55C
Roughness	Ry 2 - 3 μm
Hardness	HV 200 - 300

[0027] The test results are investigated. Inventive sliding members (1) to (5) exhibited good sliding properties without seizure (torque over or a depth of wear of more than 50 μm) under both conditions 1 and conditions 2.

[0028] On the other hand, comparative sliding member (1) was obtained by using only a PF resin (a phenolic resin) and hence seized under both conditions 1 and conditions 2. Comparative sliding members (2) to (5) were obtained by using a thermosetting resin as a base material but seized under conditions 2. Comparative sliding members (6) to (9) seized and showed a large depth of wear under conditions 2 because their base resin was PTFE.

[0029] The materials used in the experiments are as follows. The PF resin is "MILEX XL-325M" manufactured by Mitsui Chemicals Inc. The PTFE powders are the following two powders; PTFE (1): "Teflon Fine Powder 6-J (molecular weight 3,000,000 or more, and average particle size 470 μm)" manufactured by Mitsui Dupont Fluorochemicals Co., Ltd., and PTFE (2): "Lublon L-2 (molecular weight 600,000 or less, and average particle size 2 μm)" manufactured by Daikin Industries, Ltd. The barium sulfate is "BMH-100" manufactured by Sakai Chemical Industry Co., Ltd.

[0030] The average particle size of PTFE particles is preferably 300 to 600 μm. When the average particle size is as large as 300 to 600 μm, PTFE particles are made into fiber during mixing with a thermosetting resin and the like to have a large specific surface area. Therefore, the PTFE particles are distributed widely at a high density in the surface of the sliding composition 5, so that the sliding composition 5 has chemical resistance, heat resistance and excellent frictional properties owing to the excellent self-lubricating properties of the PTFE particles.

[0031] The sliding member 1 of the present invention comprising the porous sintered metal layer 4 on the backing metal layer 3 and the sliding composition 5 coating the porous sintered metal layer 4 by impregnation as described above is produced as a bearing by processing into a semi-cylinder or a cylinder.

[0032] Needless to say, the sliding member 1 of the present invention can be used not only without lubrication but also with lubrication and exhibits at both a high speed and a low speed.